Savannah River NUCLEAR SOLUTIONS℠
FLUOR • NEWPORT NEWS NUCLEAR • HONEYWELL

SRNL™ SAVANNAH RIVER NATIONAL LABORATORY
Operated by Savannah River Nuclear Solutions, LLC
We Put Science To Work

Basic Understanding of Transmutation

Steve Sheetz

Savannah River National Laboratory
Program Manager, Small Modular Reactor Pursuit Team

June 26, 2012

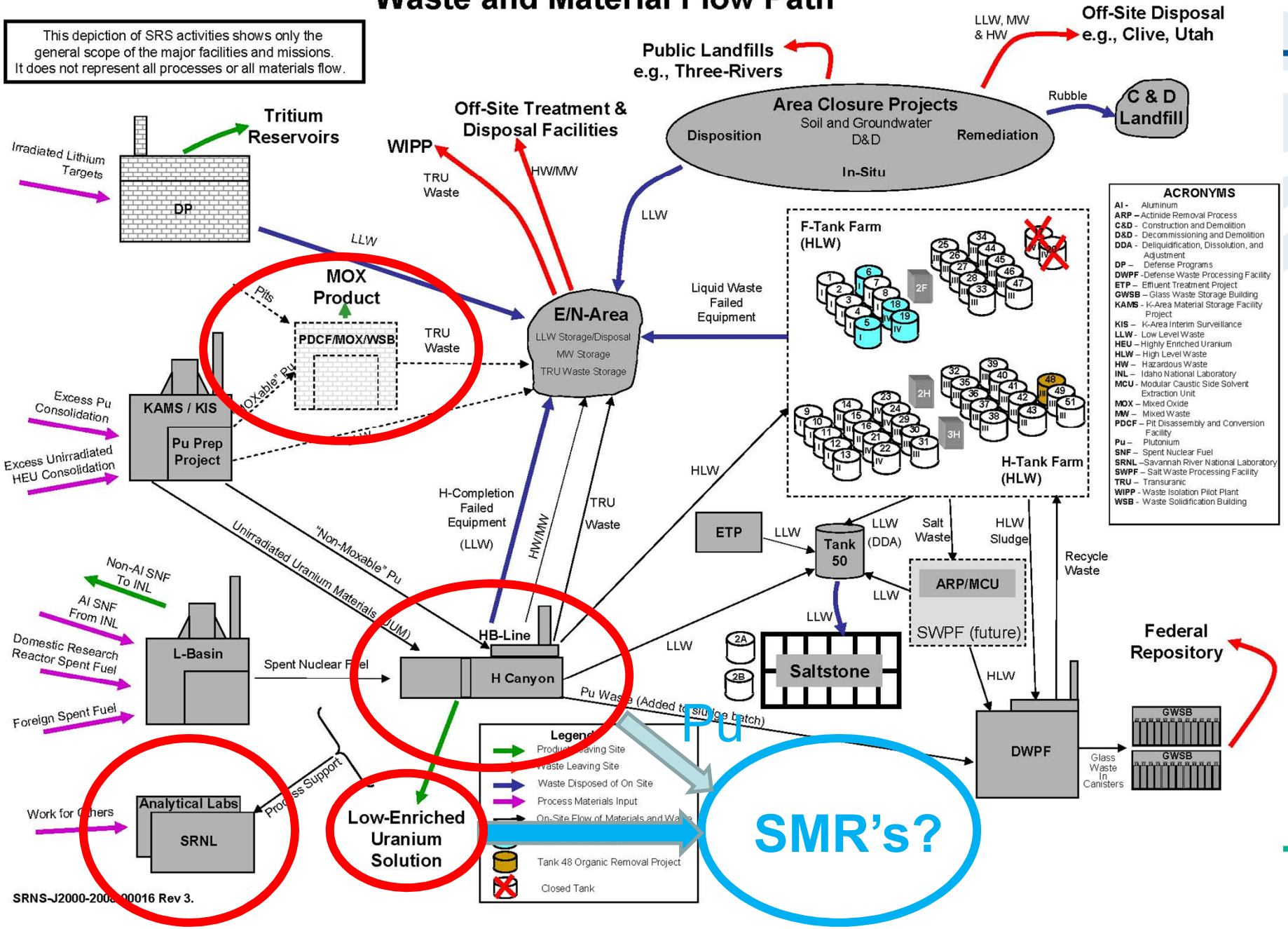
Citizens Advisory Board – Nuclear Materials Committee

U.S. DEPARTMENT OF ENERGY

Purpose

- To fulfill Nuclear Materials Committee 2012 Work Plan Topic
- Address a request from the Nuclear Materials Committee / CAB
- Provide a basic explanation of transmutation and its uses
- Describe transmutation of waste

Savannah River Site
Waste and Material Flow Path



Transmutation: A Definition

An act or instance of transmuting or being transmuted:

a: the conversion of base metals into gold or silver

b: the conversion of one element or nuclide into another by natural or artificial nuclear reaction

Bombard with Neutrons to create:

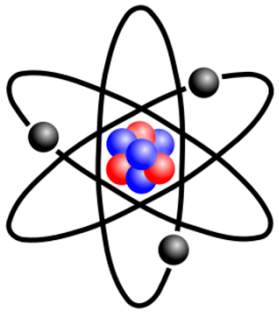
- Isotopes
- Fission products

Isotopes and Fission Products

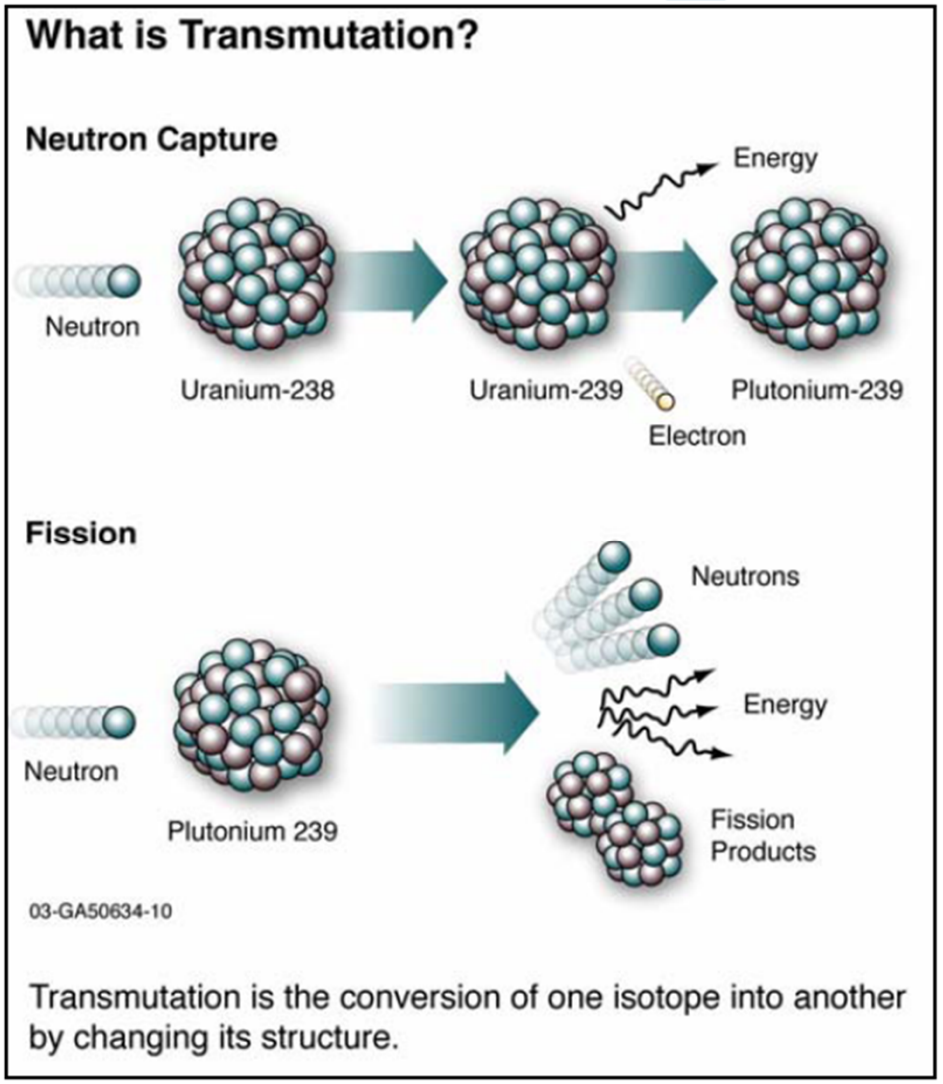
Isotope : An element with the same number of Protons but varying numbers of Neutrons – same atomic number but varying atomic mass

- About 1600 isotopes have been characterized
- Either stable or unstable (radioactive)
- Example: Co-59 + neutron => Co-60

Fission Products: The atomic fragments left after a larger atom fissions. Example - Uranium 235 often breaks into Cesium-137 and Strontium-90

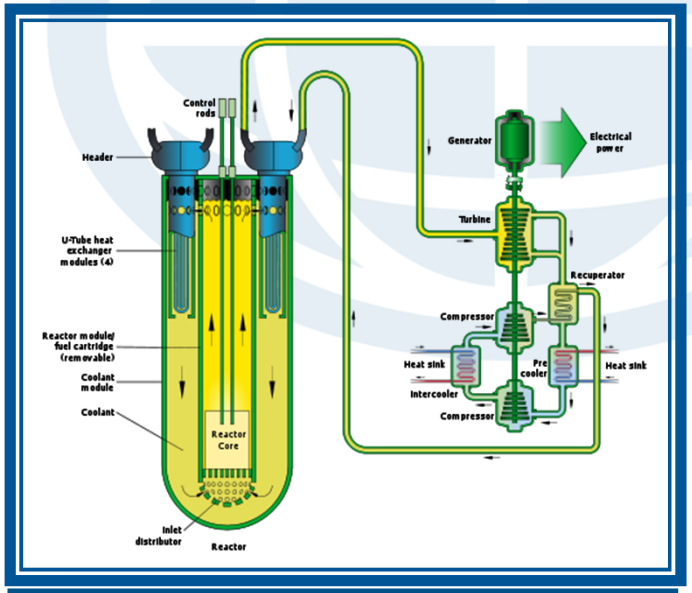


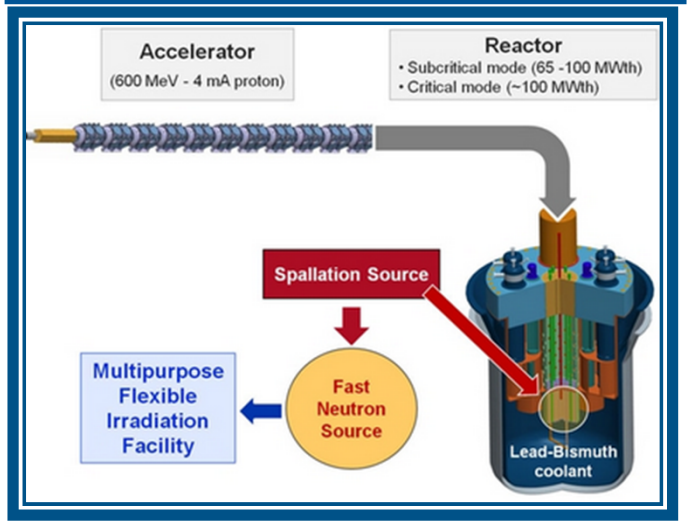
How Neutrons Cause Transmutation



Sources of Neutrons for Transmutation

- **Thermal Neutrons**
  - Light Water Reactors
- **Fast Neutrons**
  - Fast Reactors
  - Accelerator Driven Sub-Critical Reactors





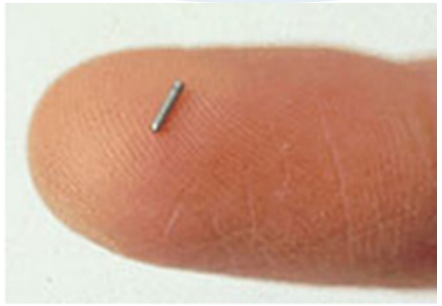
Production or Destruction

Isotope Production

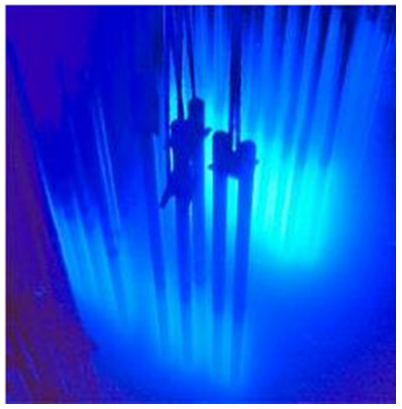
- Nuclear medicine
  - Diagnostic
  - Treatment
- Industrial
  - Inspection/testing
  - Sterilization
- Defense
  - Pu-239
  - Tritium

Waste Destruction

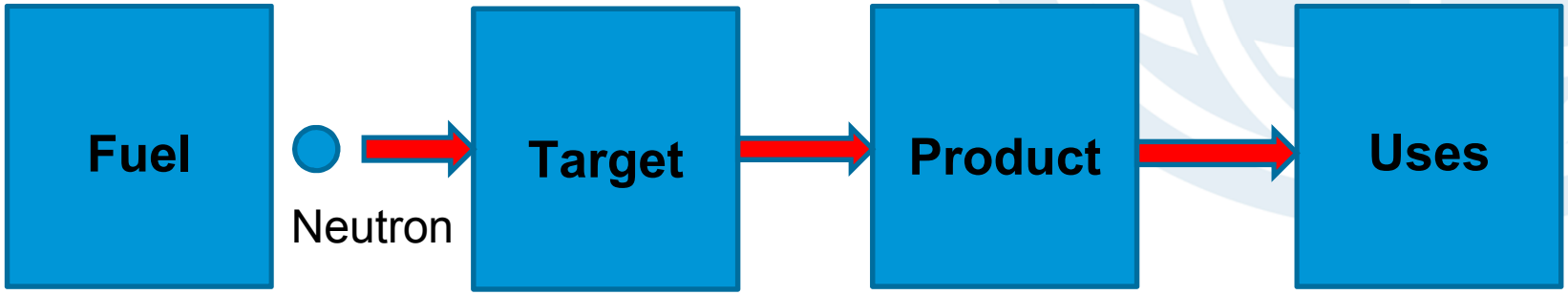
- Reduce radiotoxicity
- Destroy excess Pu



Northshore Medical Accelerator

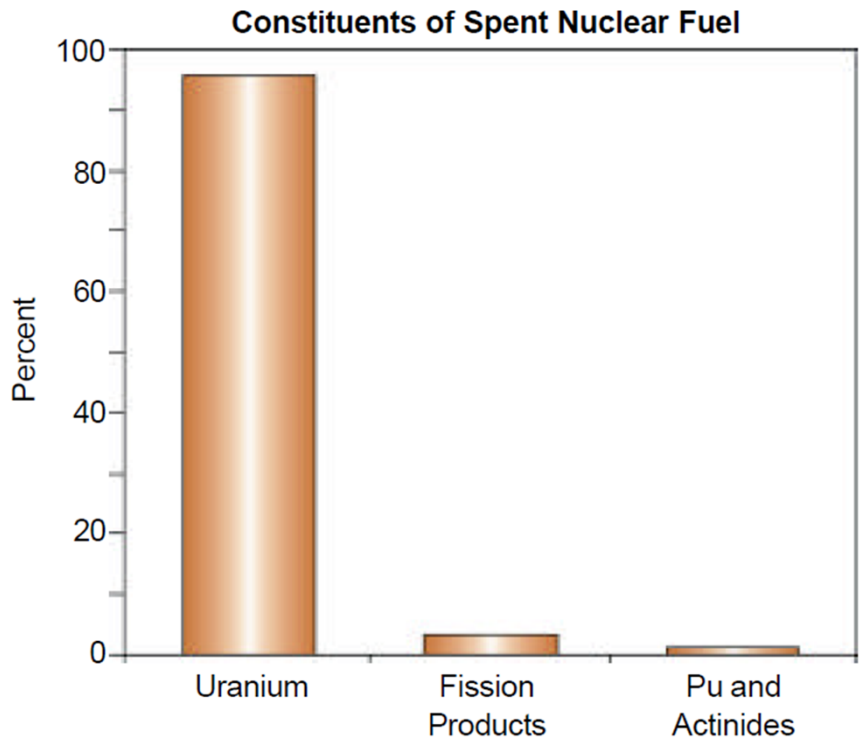


Savannah River Isotopes through the years…



U-235	U-238	Pu-239	Weapons
	Li-6	Tritium	Weapons
	Np-237	Pu-238	Heat source
	Co-59	Co-60	Medical

What is in Used Nuclear Fuel?

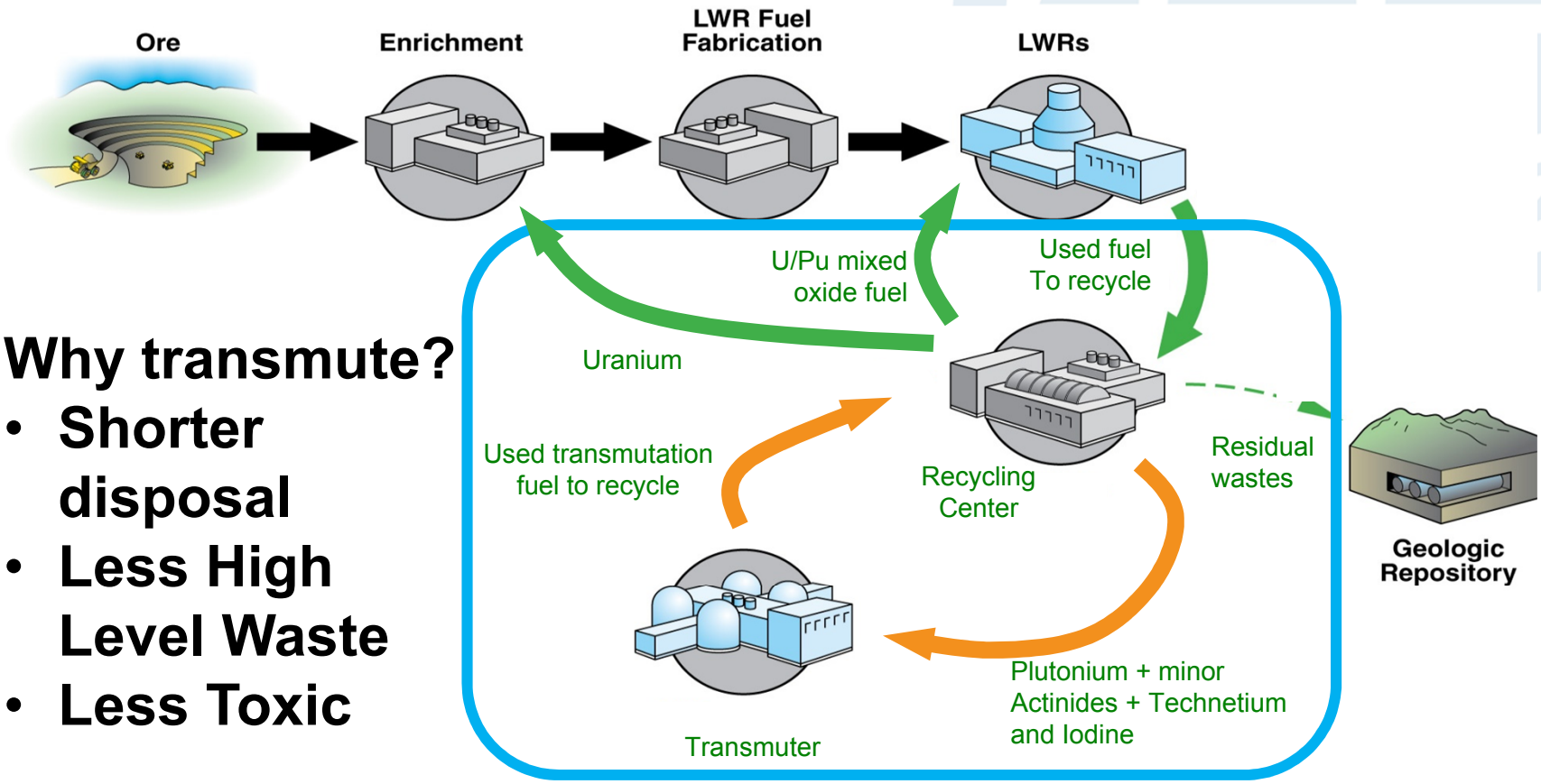


- 95.6% is uranium
- 3% is stable or short-lived fission products
- 0.3% is cesium and strontium
- 0.1% is long-lived iodine and technetium
- 0.9% is plutonium
- 0.1% is long-lived actinides

COLOR KEY

- ❑ Recycle/LLW
- ❑ Repository
- ❑ Transmute – Capture
- ❑ Transmute - Fission

Transmutation and Used Fuel Management



Why transmute?

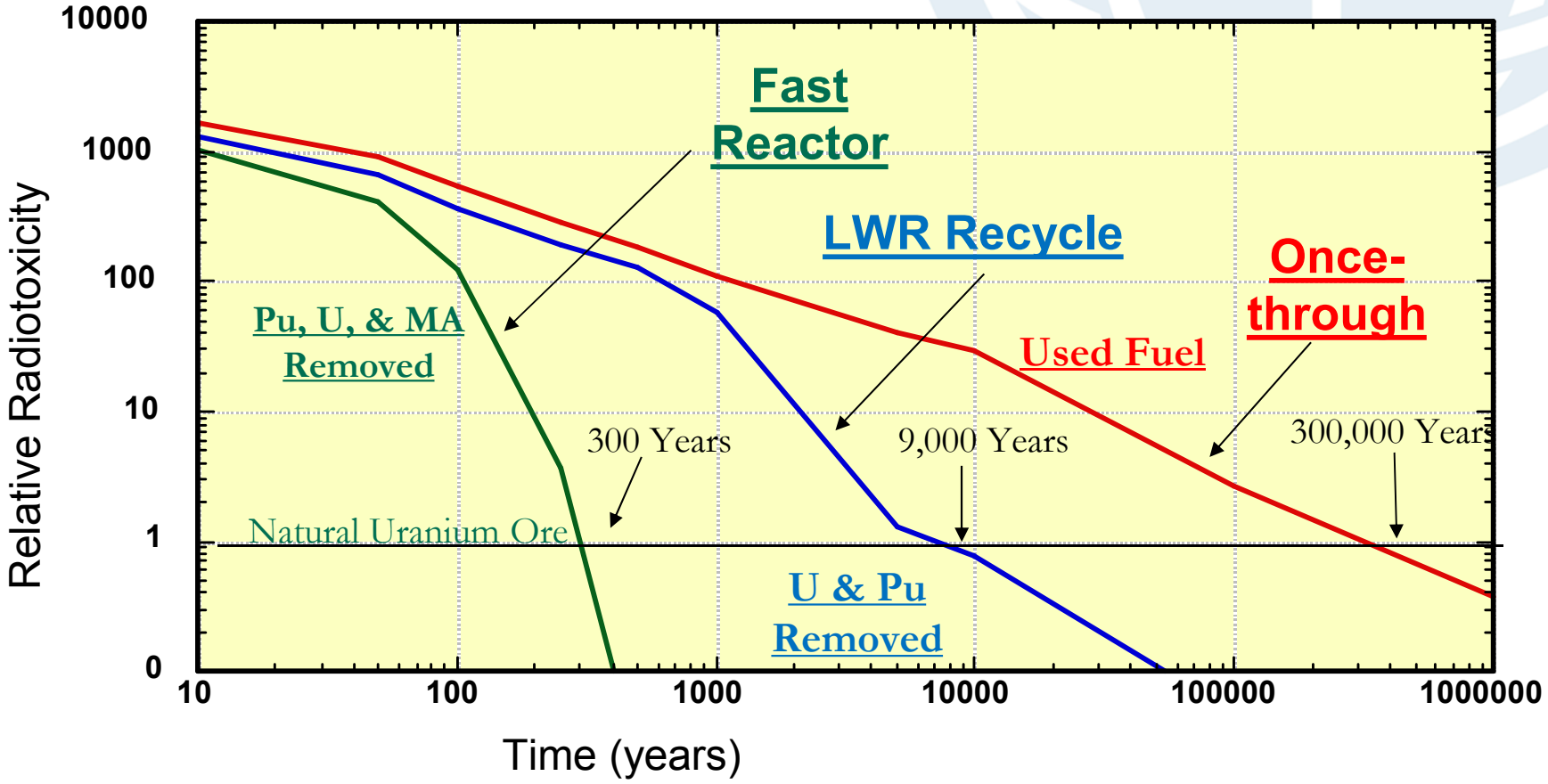
- **Shorter disposal**
- **Less High Level Waste**
- **Less Toxic**

06-GA50559-

Green = Light Water Recycle

Orange = Transmutation with Fast Neutrons

Effects of Transmutation of Commercial Fuel



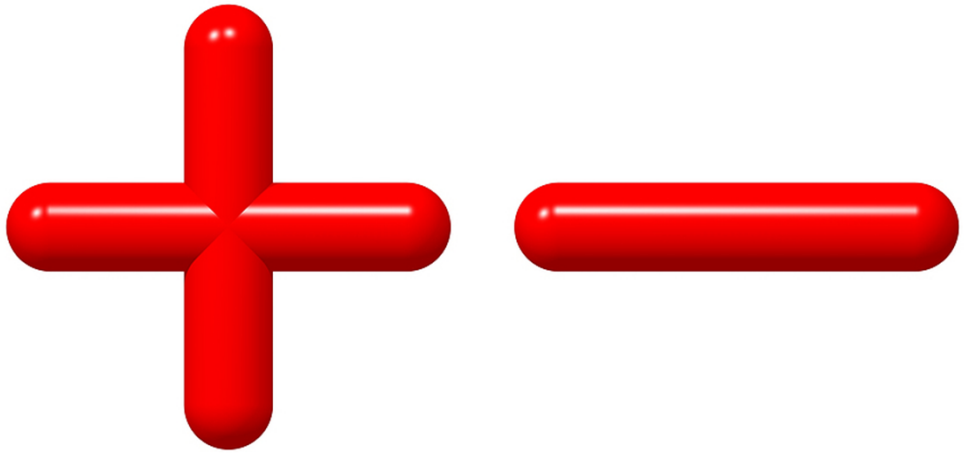
Summary – Transmutation of Waste

Benefits:

- Reduce volume
- Reduce radiotoxicity
- Destroy Plutonium
- Simpler repository

Challenges:

- Partitioning
- Costs
- Proliferation questions
- Technology development



Savannah River's Current Role in Waste Transmutation

- **This presentation for information only**
- **No currently budgeted programs**
- **Savannah River National Laboratory support has been task based from other programs**
- **Prior support provided on the following programs:**
  - Accelerator Transmutation of Waste (ATW)
  - Advanced Fuel Cycle Initiative (AFCI)
  - Global Nuclear Energy Partnership (GNEP)

Acronyms

AFCI	Advanced Fuel Cycle Initiative
ATW	Accelerator Transmutation of Waste
Co	Cobalt
GNEP	Global Nuclear Energy Partnership
Li	Lithium
LLW	Low-Level Waste
LWR	Light Water Reactor
MA	Minor Actinides
Np	Neptunium
Pu	Plutonium
SMR	Small Modular reactor
U	Uranium

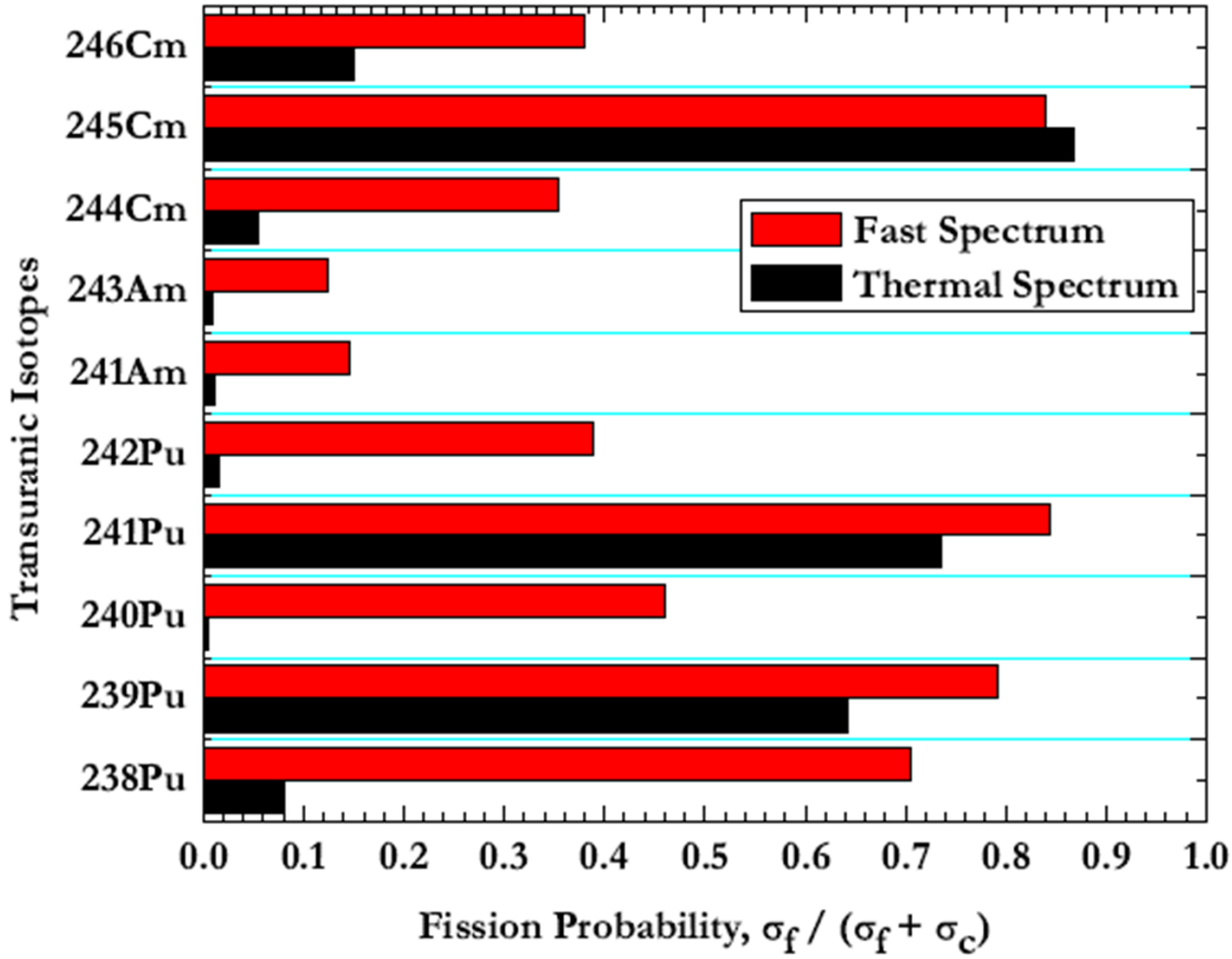
Resources / References

- http://nuclear.gov/pdfFiles/AFCI_CongRpt2003.pdf\
- http://www.isotopes.gov/outreach/reports/Medical_Isotope_Production_Use.pdf
- http://nuclear.energy.gov/pdfFiles/afciFy2005StatusRptToCongress.pdf
- *kth.diva-portal.org/smash/get/diva2:404488/FULLTEXT01*

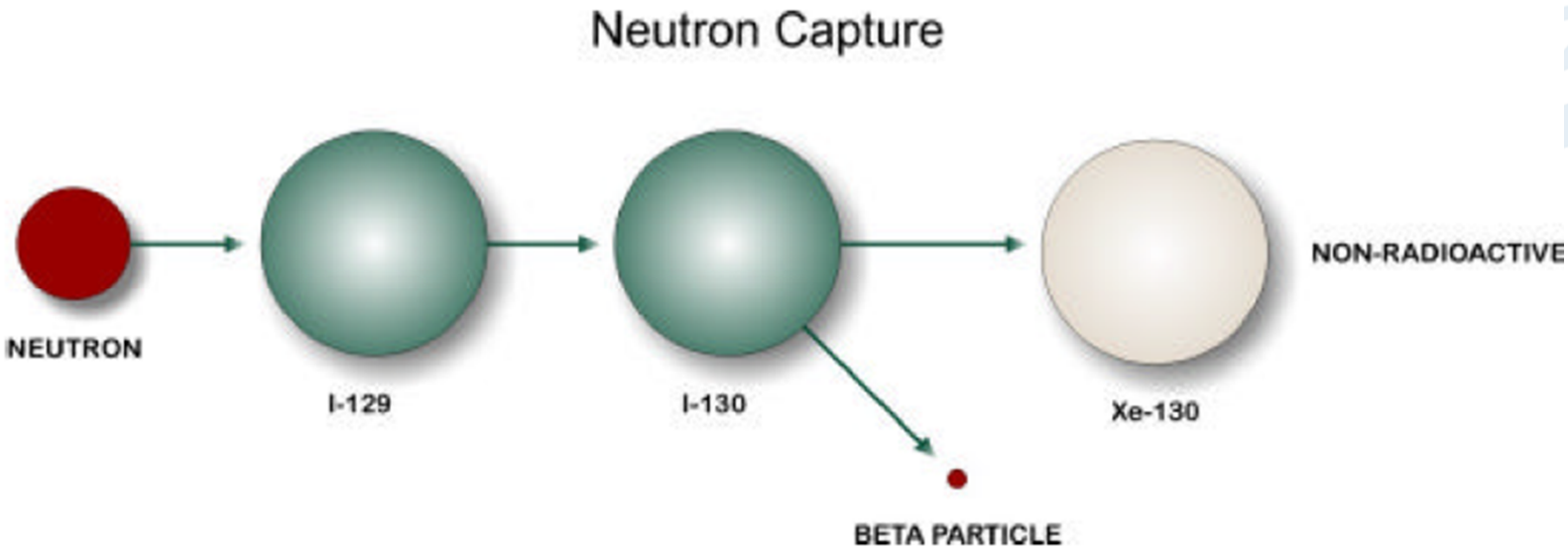
Backup Slides

- Backup Slides

Fast Versus Thermal Neutrons

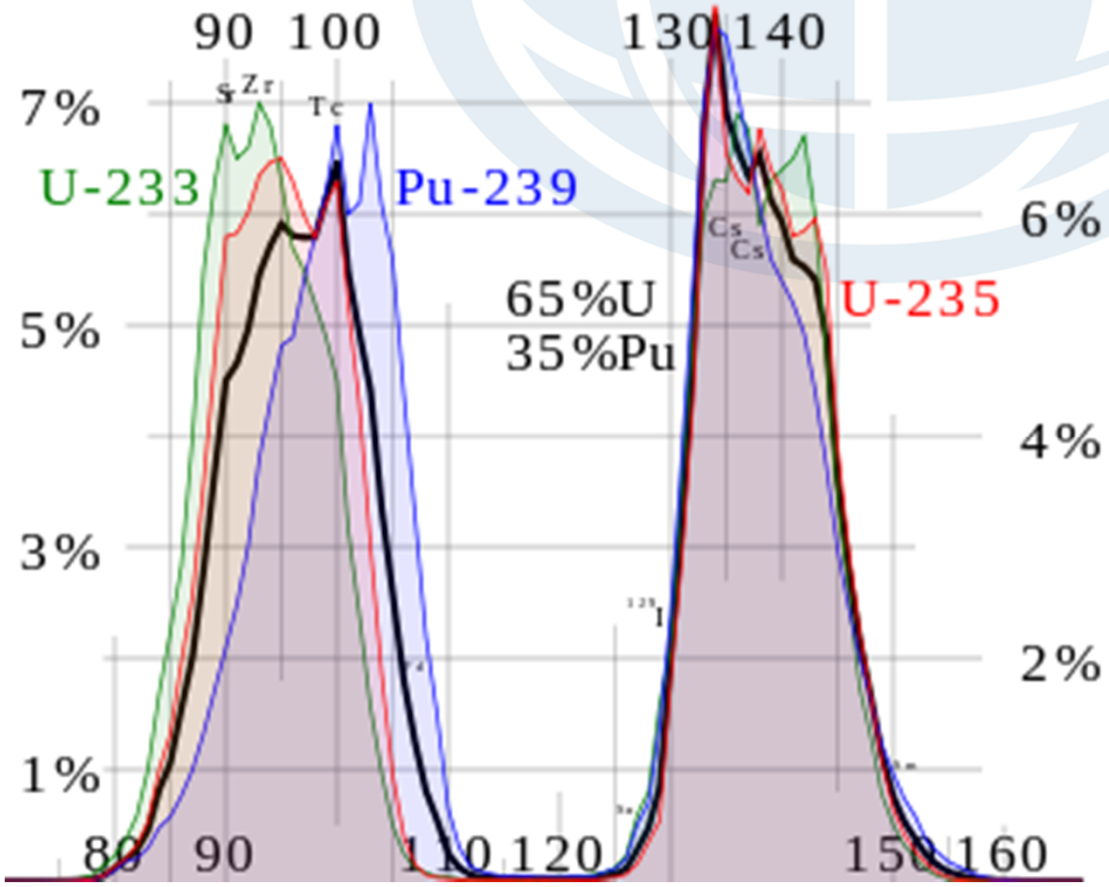


Transmutation of Iodine–129



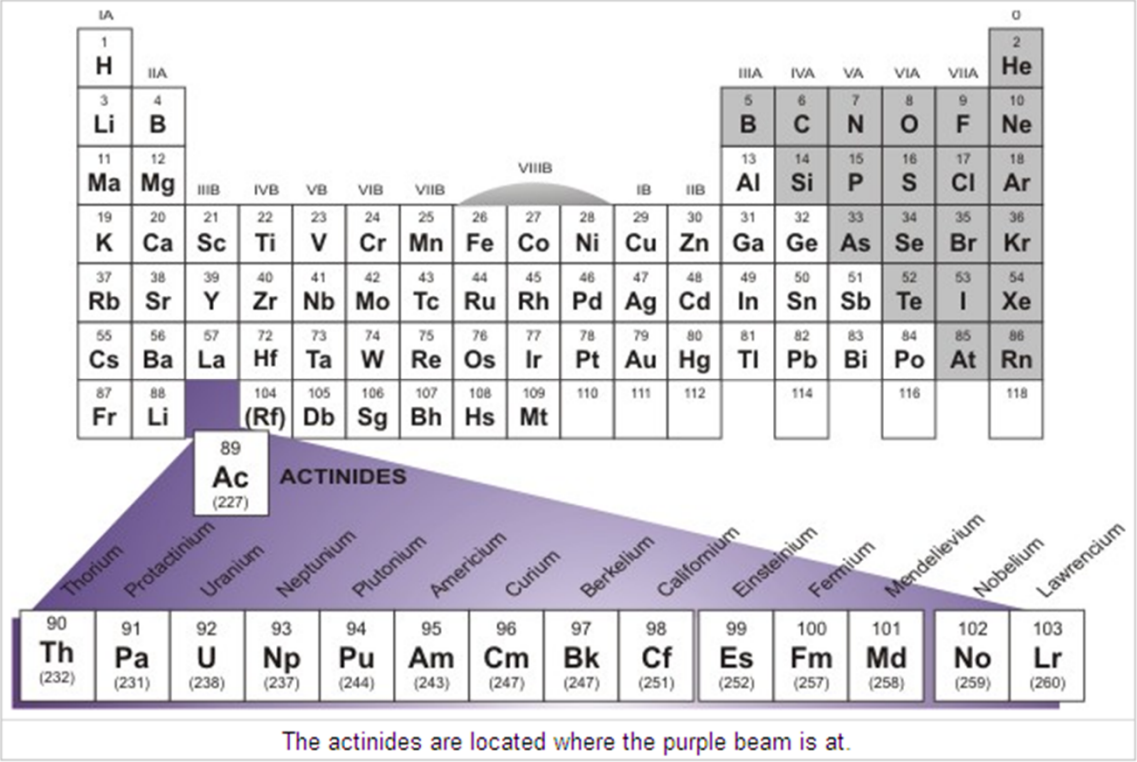
What are fission products?

- Broken parts from the fission of actinides
- Cesium-137 and Strontium-90 most common
- Approximately 30 year half-lives



What are Actinides?

- **Elements between atomic numbers between 89 and 104**
- **Uranium (U), plutonium (Pu), neptunium (Np), americium (Am), and curium (Cm) determine the long term toxicity and heat load of spent nuclear fuel**
- ***Transuranics*: higher than Uranium and include Np, Pu, Am and Cm**
- ***Minor actinides:* due to relatively low percentages in the isotopic mix in spent fuel Np, Am, and Cm**



The actinides are located where the purple beam is at.